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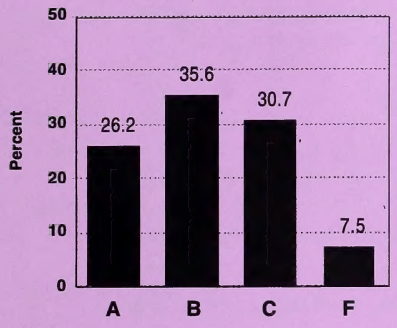
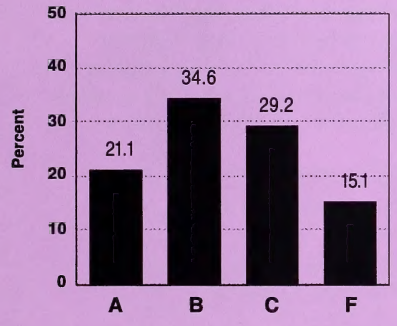
Chemistry 30

Diploma Examination Results
Examiners' Report for January 1995

School-Awarded Mark



Diploma Examination Mark



Final Course Mark

The summary information in this report provides teachers, school administrators, students, and the general public with an overview of results from the January 1995 administration of the Chemistry 30 Diploma Examination. This information is most helpful when used with the detailed school and jurisdiction reports that have been mailed to schools and school jurisdiction offices. An annual provincial report containing a detailed analysis of the combined January, June, and August results is published each year.

Description of the Examination

The Chemistry 30 Diploma Examination consists of 44 multiple-choice questions worth 55%, 12 numerical-response questions worth 15%, and 2 written-response questions worth 30% of the total examination mark.

Achievement of Standards

The information reported is based on the final course marks achieved by 6 750 students in Alberta who wrote the January 1995 examination. This represents a decrease of 327 compared to January 1994 and a decrease of 1 332 students compared to January 1993.

- 92.3% of the 6 750 students achieved the acceptable standard (a final course mark of 50% or higher).
- 22.2% of these students achieved the standard of excellence (a final course mark of 80% or higher).

Overall, student achievement in Chemistry 30 was acceptable, particularly in knowledge of core concepts. However, students had difficulty with equilibrium, and in organizing and communicating their chemistry knowledge.

Approximately 52.2% of the students who wrote this examination were female, which is similar to the percentage of females in the general population at this age group. Approximately 83.7% of this female population achieved the acceptable standard on the examination, compared to 86.3% of the male population. Approximately 18.2% of the female population achieved the standard of excellence on the examination, compared to 24.3% of the male population.

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Provincial Averages

- The average school-awarded mark was 68.7%.
- The average diploma examination mark was 66.1%.
- The average final course mark, representing an equal weighting of the school-awarded mark and the diploma examination mark, was 67.8%.

Approximately 8.9% of the students who wrote the examination in January 1995 and received a school-awarded mark had written at least one other Chemistry 30 Diploma Examination during the August 1993 to August 1994 period. This subpopulation (636) did not do as well (62.4%) as the population (6 114) whose first writing of a Chemistry 30 examination (66.5%) was in January 1995. However, the group of students who rewrote the chemistry examination increased their score, on average, from 48.9% to 62.4%.

Results and Examiners' Comments

This examination has a balance of question types and difficulties. It is designed so that students capable of achieving the acceptable standard will obtain a mark of 50% or higher and students achieving the standard of excellence will obtain a mark of 80% or higher. Future examinations will continue to require students to demonstrate clarity in their thinking and an understanding of concepts by applying their knowledge to new and novel situations in a concise and organized fashion. Students who achieved these expectations were successful in this examination.

In the following table, diploma examination questions are classified by question type: multiple choice (MC), numerical response (NR), and written response (WR). The column labelled "Key" indicates the correct response for multiple-choice and numerical-response questions. For numerical-response questions, a limited range of answers was accepted as being equivalent to the correct answer. For multiple-choice and numerical-response questions, the difficulty indicates the percentage of students answering the question correctly. For written-response questions, the difficulty is the mean score achieved by students who wrote the examination.

Questions are also classified by general learner expectations.

Knowledge–
- GLE 1 Quantitatively Predicting Outcomes
- GLE 2 Qualitatively Analyzing Systems
- GLE 3 Relationships in Energy Transfer
- GLE 4 Relationships in Electron Transfer
- GLE 5 Relationships in Equilibrium systems
- GLE 6 Relationships in Proton Transfer

Skills–
- SPSC Scientific Process Skills and Communication Skills.

Science, Technology, Society–
- STS Connections Among Science, Technology, & Society.

Blueprint

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPSC	STS
MC 1	D	73.2		√	√					
MC 2	D	78.2	√		√				√	
NR 1	49.0	93.9	√		√				√	
NR 2	3.52	84.9	√		√				√	√
MC 3	C	94.5		√	√				√	
MC 4	C	52.2	√		√				√	√
MC 5	C	54.5		√	√				√	√
MC 6	D	52.3	√					√	√	√
MC 7	B	71.4		√				√		√
MC 8	D	52.1		√		√			√	√
MC 9	A	58.4		√	√				√	√
MC 10	A	68.7		√	√				√	
MC 11	B	60.5		√	√					
MC 12	D	74.0		√	√				√	
MC 13	B	51.5		√	√					

Question	Key	Difficulty	GLE 1	GLE 2	GLE 3	GLE 4	GLE 5	GLE 6	SPSC	STS
MC 14	B	96.0		√		√				
MC 15	A	86.3		√		√				
NR 3	7130	77.9	√			√				
MC 16	B	59.7		√		√			√	√
MC 17	D	66.2		√		√				√
NR 4	0.42	61.7	√			√			√	
MC 18	D	81.9		√		√				
MC 19	C	73.9		√		√				
MC 20	A	71.3		√		√			√	
MC 21	C	81.4		√		√			√	
NR 5	1.63	65.7	√			√			√	
NR 6	1.24	61.9	√			√			√	
MC 22	D	48.6	√				√	√	√	√
MC 23	C	60.8		√			√			√
MC 24	D	42.6		√			√	√	√	√
MC 25	A	49.4	√					√	√	
MC 26	B	84.7		√				√		√
MC 27	A	51.6		√				√		√
MC 28	A	21.3	√					√	√	√
MC 29	D	74.8		√			√	√		√
MC 30	A	65.7	√		√		√		√	√
MC 31	B	90.4	√				√		√	√
MC 32	C	85.4		√			√	√		√
MC 33	A	68.2	√					√	√	√
MC 34	C	19.9	√				√	√	√	
NR 7	1.15	67.4	√				√		√	
NR 8	7.05	90.2	√					√	√	
MC 35	B	72.8		√			√	√		
NR 9	2468*	87.1		√				√	√	
NR 10	5371	43.1		√			√	√	√	
MC 36	A	93.0	√					√	√	
MC 37	C	78.2		√				√		
NR 11	2346*	77.4			√				√	√
NR 12	4236**	69.1			√				√	√
MC 38	B	55.1		√			√	√		
MC 39	B	49.0		√				√	√	
MC 40	A	75.7	√					√	√	
MC 41	B	82.4	√					√	√	
MC 42	C	81.3		√				√	√	
MC 43	B	86.4	√					√	√	
MC 44	A	75.3		√				√		
WR 1	—	55.0		√		√			√	
WR 2	—	63.2	√	√	√				√	√

* in any order

** 2436 or 2346 also acceptable

Subtest

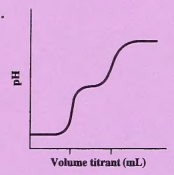
When analyzing detailed results, please bear in mind that subtest results **cannot** be directly compared. Results are in average raw scores.

- Multiple choice and numerical response: 38.5 out of 56
- Written Response: 14.3 out of 24

GLE 1	Quantitatively Predicting Outcomes	14.9	out of	22
GLE 2	Qualitatively Analyzing Systems	28.9	out of	42
GLE 3	Relationships in Energy Transfer	9.1	out of	13
GLE 4	Relationships in Electron Transfer	14.6	out of	21
GLE 5	Relationships in Equilibrium Systems	7.3	out of	12
GLE 6	Relationships in Proton Transfer	17.9	out of	27
Skills		26.9	out of	41
STS		12.5	out of	20

40. Which of the following graphs **best** represents the neutralization of a diprotic acid by the continuous addition of 0.10 mol/L $NaOH_{(aq)}$?

*A.



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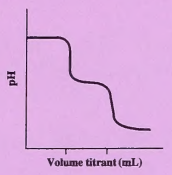

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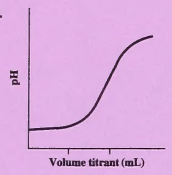
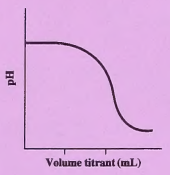


D.



Chromium(VI) oxide is used to form the highly acidic "chromic acid" in chromium plating solution.
Production of "chromic acid" is
$2\ CrO_{3(s)} + H_2O_{(l)} \rightarrow H_2Cr_2O_{7(aq)}$.
The "chromic acid" ionizes 100% in water as
$H_2Cr_2O_{7(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HCr_2O_7^-{}_{(aq)}$.

28. What is the pH in a chromium plating solution in a 1000 L tank when 240.0 g/L of $CrO_{3(s)}$ is dissolved?

***A.** –0.0792
B. –0.3802
C. 2.620
D. 2.921

Multiple-Choice and Numerical-Response Questions

The following questions were selected for discussion because they exemplify what is required to meet the acceptable level and the level of excellence.

Multiple-choice question 40: Most students (75.7%) were able to identify the shape of the graph for the titration of a diprotic species with a strong base. Only 7.5% of all the students assumed that a diprotic acid would have a high pH and that the titration of the acid by the base would lead to a lower pH. The majority of students who attained the acceptable standard but not the standard of excellence (77.5%) and the standard of excellence (97.5%) had success on this question; whereas, students who did not attain the acceptable standard had limited success (37.2%). The results for this question suggest that students who do not attain the acceptable level do not understand fundamental concepts such as pH and cannot relate these concepts graphically to a titration curve.

Multiple-choice question 28: As expected, most students (78.7%) could not successfully apply concepts from the acid-base unit to a redox situation; only 21.3% of all students were successful in answering this question correctly. The most common mistake (56.9%) made by students was to use a 1:1 ratio in their calculations rather than the required 2:1. Part of the problem stems from the requirement of the students to combine two redox equations to yield a "net redox-reaction." It appears that most students did not utilize all the information given to them. The other common difficulty students had was in understanding the significance of the unit g/L. As a result, 48.9% of the students used the volume of the tank in their calculations. The majority of students who attained the standard of excellence (51.8%) were successful in solving this question; whereas, students who attained the acceptable standard but not the standard of excellence had very limited success (14.4%), and students who did not attain the acceptable standard had very poor success (8.2%) on this question.
This result suggests that students who attain the standard of excellence are able to apply concepts from one unit to another unit.

Numerical Response

3. The oxidation number for chlorine in $HClO_4$, HClO, $HClO_2$, and Cl_2 are respectively _____.
(Record all four digits on the answer sheet.)

Answer: **7130**

Equations

$HOCN_{(aq)} + C_3H_5O_3^-{}_{(aq)} \rightleftharpoons OCN^-_{(aq)} + HC_3H_5O_{3(aq)}$ Products favoured

$HC_3H_5O_{3(aq)} + C_6H_5COO^-_{(aq)} \rightleftharpoons C_3H_5O_3^-{}_{(aq)} + C_6H_5COOH_{(aq)}$ Products favoured

$HOCN_{(aq)} + IO_3^-{}_{(aq)} \rightleftharpoons OCN^-_{(aq)} + HIO_{3(aq)}$ Reactants favoured

Key

1 $C_6H_5COOH_{(aq)}$	**4** $OCN^-_{(aq)}$	**7** $HC_3H_5O_{3(aq)}$
2 $C_6H_5COO^-_{(aq)}$	**5** $HIO_{3(aq)}$	**8** $C_3H_5O_3^-{}_{(aq)}$
3 $HOCN_{(aq)}$	**6** $IO_3^-{}_{(aq)}$	

Numerical Response

10. The acids, ordered from strongest to weakest, are _____.
(Record all numbers in your sequence on the answer sheet.)

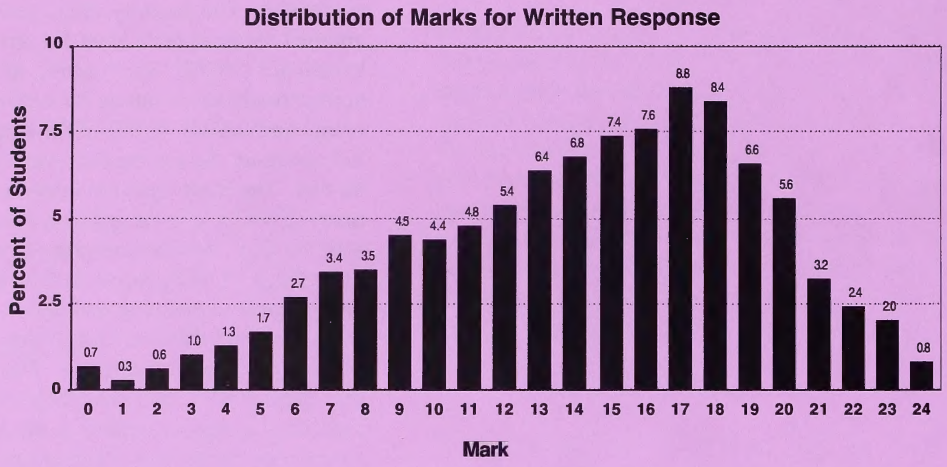
Answer: **5371**

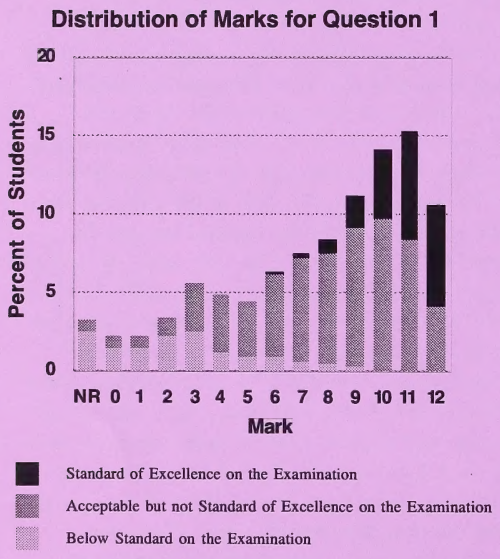
Numerical-response question 3: As expected, most students (77.9%) could determine the oxidation numbers. Virtually all students who attained the level of excellence (96.7%) were successful. The majority of the students who attained the acceptable level but not the level of excellence (79.9%) were capable of assigning correct oxidation numbers for each of the compounds. Only 42.9% of the students who did not attain the acceptable level were able to do this. The most common mistake students made (3.4%) was in assigning a value of 2 as the state for Cl_2. Another common mistake was in assigning a –1 oxidation state to hydrogen for the hydrogen-containing compound. The only other mistake identified (1.4%) was not assigning a value to hydrogen. This suggests that students achieving the acceptable level are capable of assigning oxidation states to compounds containing complex ions.

Numerical-response question 10: This question discriminated very well between students who attained the standard of excellence and those who did not. The question involved the ordering of four acids based upon their strength, and 43.1% of all students were able to do this. Most of the students attaining the level of excellence (80.6%), few of the students who attained the acceptable standard but not the standard of excellence (38.5%), and very few of those who did not attain the acceptable standard (9.8%) were successful in solving this question. In the previous related question, numerical-response question 9, 87.1% of the students were able to identify the four bases; thus, one would expect that 87.1% of the students should be able to recognize an acid. Therefore, the expected difficulty came from the ordering of the species and not from the identification. The most common mistake came from the inability to correctly rank the acids based upon the provided data (33.9%). The other mistake identified was students' inability to identify all four acids (23.1%). The results for this question suggest that students attaining the level of excellence are capable of distinguishing between acids and bases and analyzing data to rank order substances.

Written-Response Questions

The level of achievement on the written-response section was as expected: almost three-quarters of the students (71.2%) achieved a mark of 12 or higher out of 24. The average mark on the written-response section was 14.3 or 59.3% of the available marks.




Distribution of Marks for Question 1
Percent of Students
20
15
10
5
0
NR 0 1 2 3 4 5 6 7 8 9 10 11 12
Mark
Standard of Excellence on the Examination
Acceptable but not Standard of Excellence on the Examination
Below Standard on the Examination

Question 1 was answered as well as expected. The question was selected to measure students' ability to apply their understanding of redox chemistry. Students were required use their knowledge to write an experimental procedure to investigate a new concept. Students who did not attain the acceptable level were expected to score between 0 to 5, and 83.2% did so. They averaged 2.78 by drawing a cell. However, their selection of reagents and/or diagrams indicated that they had difficulty in distinguishing between electrolytic cells and voltaic cells. They were unable to write a procedure and to correctly identify variables. Most of these students' responses were very ambiguous and poorly organized and communicated. Spelling, grammatical, and labelling errors were the norm.

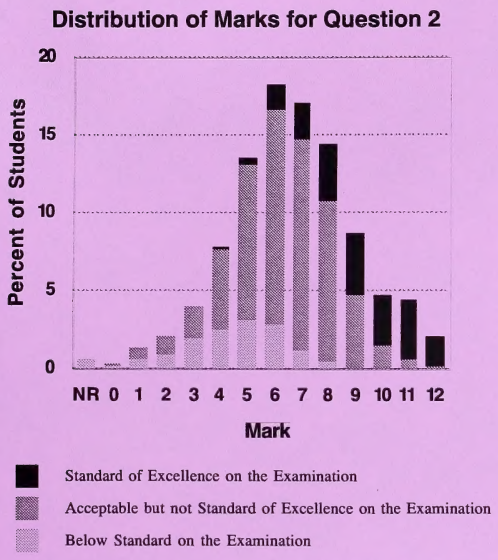
Students who attained the acceptable level but not the level of excellence on the examination were expected to score in the range of 6 to 10, and 58.9% did so. They averaged 7.79 by writing a procedure that could be performed and generate data. However, most students had difficulty in selecting appropriate reagents. Lithium, calcium, and sodium metals were commonly selected as anodes, and fluorine was a popular choice as the cathode. As a result, their valid procedures would not generate data that could be used to confirm or refute the original premise. All of these students varied the concentration in their procedure. However, they usually varied both reagents concentrations rather than selecting one reagent to vary and the other to be held constant. They also set up a reference (control) cell and then compared other cells to the reference cell.

Neither of these approaches is invalid, and both indicate a weakness in understanding of experimental design. As a result, these students had difficulty in defining the experimental variables. Most of these students' responses were not well organized and contained omissions, such as how the two half-cells were connected, which led to some ambiguity.

Students who attained the level of excellence were expected to score 11 or better, and 62.7% did so. They averaged 10.6 by clearly communicating their answers and presenting a procedure that enabled them to gather sufficient data to confirm or refute the statement that "the electrical potential available from a voltaic cell may be affected by the concentration of the solutions used." Most responses were very well organized but, unfortunately, the majority were very wordy. These students selected appropriate reagents for a functional voltaic cell. They held the concentration of the anode solution constant and varied the concentration of the cathode solution. Their selection of concentrations showed thought (e.g., 0.10 mol/L, 0.010 mol/L, and 0.0010 mol/L). Several of these students came up with alternative procedures that worked well and solved the problem. Regardless of the approach taken, these students generally showed good communication and organizational skills.

The results on this question suggest that all students attaining the acceptable standard are able to write a procedure capable of generating data to confirm or refute a premise. The students who attain the level of excellence can select appropriate reagents and concentrations. The results further suggest that all students could profit from paying attention to the correct identification and spelling of laboratory materials.

On this 12-mark question, the average mark was 6.60 or 55.0% of the available mark.


Distribution of Marks for Question 2
Percent of Students
20
15
10
5
0
NR 0 1 2 3 4 5 6 7 8 9 10 11 12
Mark
Standard of Excellence on the Examination
Acceptable but not Standard of Excellence on the Examination
Below Standard on the Examination

Question 2 was answered better than expected by the student at or close to the acceptable standard. Students who did not meet the acceptable level were expected to score up to 5, and 67.8% met this expectation. They averaged 4.40 because they knew that a kinetic energy change was involved and required the use of "mcΔt." Unfortunately, they were unable to determine the appropriate change in temperature and were also unable to recognize that a change in potential energy was also involved. These students had difficulty in identifying a technology from the data and hence had difficulty in selecting an industry and a product that utilized their technology. However, most were able to come up with an environmental concern, but most of these were not linked either to the original question or to the industry that they had selected in the preceding part of the question. As a result, markers had to interpret these students' responses, which, in many cases, contained convention errors.

Students who attained the acceptable standard but not the standard of excellence were expected to score up to 9 and scored, on average, 6.37. In total, 66.0% of these students met this expectation. They determined either the amount of energy involved in cooling the water or in the condensation of water, but not both. Some of these students had difficulty in determining the correct "Δt" for the kinetic energy change. They were able to identify a valid industry and its product. They were also able to identify an environmental concern, but in most cases their responses were unclear as to how the concern related to the original question or the industry they selected. The most common misconception they had was that hydroelectric plants utilized the "technology" in the question. These students were able to communicate their ideas well enough to the markers so that little, if any, interpretation was required.

Students who attained the level of excellence were expected to score 10 or better and averaged 8.98 for this question, with only 8.98% attaining a perfect score. They were able to identify that a change in potential and kinetic energy was occurring and to determine the correct answer. They had no difficulty in selecting an appropriate industry and its product, and in identifying an appropriate environmental concern. These students answered the question as a whole, rather than as three independent "smaller" questions. They were very elaborate in their explanations and were careful

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to cover all facets of the question. They were very careful to link all their statements together. The only area of weakness noted was careless errors involving significant digits and units. These students presented their answers in a concise, organized fashion and expressed themselves clearly to the markers so that no interpretation was required.

The results on this question suggest that all students attaining the acceptable standard are capable of determining the amount of energy required to change the temperature of water or to condense water, and they can extract key concepts. They can recognize links between concepts and the "real world."

Students attaining the standard of excellence do so because they can analyze a situation and correctly determine the quantities involved. They can establish links between concepts that are learned and how those concepts can be applied in other settings such as industry.

On this 12-mark question, the average mark was 7.58 or 63.2% of the available mark.

For further information, contact Don Loerke or Lowell Hackman at the Student Evaluation Branch, 403-427-0010.